

Description

FUEL INJECTOR WITH NON-METALLIC TIP INSULATOR

5 Technical Field

The present invention relates generally to fuel injectors, and more particularly to an injector with a non-metallic insulator attached to a portion of the injector tip.

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Background Art

In most diesel engines, fuel injectors are positioned such that at least a portion of the injector tip protrudes into the engine combustion space. The injector tip is thus exposed to the high temperatures and pressures from fuel combustion and engine compression release braking. In these injectors which employ a needle valve to control the fuel spray, the valve seat can potentially be heated to close to its tempering temperature during engine compression release braking. During normal engine operation, the fuel travelling through the injector tip carries heat away. During engine braking, however, fuel spray is halted and the injector tip is thus more susceptible to heat transfer from the air in the cylinder.

Depending on the capabilities of the individual system, engine braking can be executed in a four cycle or two-cycle fashion, placing a retarding torque on the engine by forcing the pistons to compress air without a subsequent power stroke. In addition, it might be desirable to operate the engine

such that the engine brake is used in combination with an exhaust valve or variable geometry turbo. In four-cycle engine braking, air is compressed within a cylinder by every other upward piston stroke. In two-cycle engine braking, air is compressed during every upward stroke. Once compressed, the air is released through an exhaust line or, in boosted engine braking, released into another cylinder via the exhaust manifold to add to that cylinder's initial mass and pressure before its compression stroke.

Boosted engine braking is a useful means of applying even higher retarding torques to the engine. However, this boosted compression of the air tends to heat the injector tip substantially, particularly in two-cycle boosting applications. In addition, the injector tip can be heated substantially during periods of simultaneous engine braking and exhaust braking. If the compressed air is allowed to heat the injector nozzle valve seat to its tempering temperature, the hardness of the valve seat material can be reduced. Because the valve seat is subjected to repeated impacts by the needle valve member, softening of the valve seat material can result in quicker wear and distortion of the seat, leading to improper sealing. Additionally, weakening of the metal in the area of the valve seat can accelerate fatigue, which can eventually lead to tip breakage and catastrophic engine failure. Exotic metal alloys with higher tempering temperatures could be used in the injector tip, however, the use of these materials is often cost-prohibitive. It is thus desirable to

develop a new method of protecting the injector tip from overheating.

Heat insulating coatings and structures are known in the art and have been employed in internal combustion engines for some time. Coating the combustion chamber surfaces with a non-metallic insulator allegedly results in higher combustion temperatures and consequently more complete fuel burning. Similar coatings have been used in engine exhaust systems to maintain higher exhaust temperatures, reducing undesirable emissions. These methods appear to serve their intended purpose, which is to enhance the thermal efficiency of internal combustion engines. However, such methods are directed to treatment of relatively large surfaces within the combustion chamber, and to ensuring higher combustion temperatures rather than protecting engine components from overheating. One example of such a coating method can be found in U.S. Patent No. 5,384,200, issued to Giles et al. on January 24, 1995. The Giles method involves depositing a porous ceramic material comprised of 10%-15% volume porosity Yttria partially stabilized zirconia, or 10%-15% volume porosity Ceria-Yttria partially stabilized zirconia on a metallic layer to maintain the combustion space at a higher temperature during combustion. However, Giles does not contemplate thermal coating of the injector tip, presumably because doing so would have only a negligible effect on enhancing thermal efficiency.

The present invention is directed to overcoming one or more of the problems set forth above.

Disclosure of the Invention

A fuel injector is provided which includes an injector body with a metallic tip. A non-metallic  
5 insulator is attached to a portion of the outer surface of the tip.

In another aspect, the present invention provides a method of reducing injector tip  
overheating. This method includes the steps of  
10 providing a fuel injector with a metallic tip having an outer surface, and attaching a non-metallic insulator to a portion of the outer surface of the tip.

In still another aspect, the present  
15 invention provides an engine. The engine includes a housing, to which a plurality of fuel injectors are attached. Each of the fuel injectors has a metallic tip with an outer surface, and a non-metallic insulator is attached to the tip and covers a portion  
20 of its outer surface. Each of the injectors are positioned at least partially within an engine cylinder. The engine provided includes at least one engine compression release brake.

25 Brief Description of the Drawings

Figure 1 is a partial sectioned side view of a fuel injector according to the present invention;

Figure 2 is a diagrammatic representation of an engine with an engine compression release brake  
30 according to present invention.

Best Mode for Carrying Out the Invention

Referring to Figure 1, there is shown a partial sectioned side view of a fuel injector 10 according to the present invention. Injector 10 has an injector body 11 with a metallic tip 12. A needle valve 19 is positioned within injector 10 and alternately opens or closes a valve seat 20. A non-metallic insulator 16 is attached to a portion of the outer surface 13 of injector tip 12. Injector body 11 defines a plurality of nozzle outlets 18 which fluidly connect to a sac 24 below valve seat 20.

Injector body 11 has a centerline 14 which is perpendicular to a plane 15. Plane 15 intersects injector body 11 and centerline 14 at a point which preferably lies between valve seat 20 and nozzle outlets 18. In the preferred embodiment, insulator 16 is attached to the portion of the outer surface 13 of injector tip 12 which lies above plane 15 such that nozzle outlets 18 are not covered. Also in the preferred embodiment, insulator 13 is ceramic and is preferably less than about three millimeters thick. The ceramic material is preferably sized and sufficiently resistant to heat transfer that valve seat 20 is not heated to or above its tempering temperature during combustion or braking.

Referring now to Figure 2, there is shown an engine 40 according to the present invention, which is preferably a four-cycle compression-ignition (diesel) engine. Engine 40 includes at least one fuel injector 10 from Figure 1 and at least one engine compression release brake 42 which are attached to an engine housing 41. A piston 43 is shown which has a piston

face 44 exposed to a combustion chamber 45. Injector 10 is preferably positioned such that it extends partially into combustion chamber 45. Combustion chamber 45 can be opened to an exhaust line 49 by an engine compression release brake valve 48, and is controlled by an engine brake actuator 46 which moves an engine compression release valve member 47 to an open position when piston 43 nears top dead center during engine braking. Positioned in exhaust line 49 is an exhaust valve 50, that is movable between a first position in which flow through exhaust line 49 is unrestricted and at least one other position in which flow through exhaust line 49 is restricted.

#### 15 Industrial Applicability

Referring to Figure 2, when engine braking is desired, fuel injection through injector 10 is halted and engine brake valve 48 is closed. During a compression stroke, piston 43 moves upward and compresses air in chamber 45. When piston 43 nears its top dead center position, engine brake actuator 46 moves engine brake valve member 47 to open engine brake valve 48. Consequently, air compressed by the upward movement of piston 43 is expelled into the exhaust line through valve 48. This compression of air in chamber 45 requires a substantial amount of the engine's energy, which is lost when valve 48 is opened and the pressurized air is expelled. This consumption of energy produces a retarding torque on the engine, corresponding to the energy required to compress the air. As piston 43 begins to move down, an intake valve (not shown) is preferably opened to allow air to

be drawn back into chamber 45 in preparation for the next compression cycle if desired.

In a four-cycle engine braking scheme, each engine piston compresses air every other stroke, heating the air substantially as it is compressed. Thus, during periods of engine braking, the injector tip is subjected to relatively high temperatures. In addition to these periods of engine braking, exhaust valve 50 can be adjusted such that a flow restriction is present in exhaust line 49. When this flow restriction is present in exhaust line 49, evacuation of compressed air from combustion chamber 45 is slowed, corresponding to a period of exhaust braking. During periods of simultaneous engine braking and exhaust braking, air within combustion chamber 45 becomes hotter still, subjecting injector tip 12 to even higher temperatures.

In a two-cycle scheme, the pistons compress air every time they travel toward their top position. The more frequent compression strokes required for two-cycle engine braking result in greater retarding torque on the engine than in four-cycle braking, but have the negative effect of increased heating of the engine components. This problem is compounded in systems where engine braking is boosted. In boosting applications, some of the air compressed by one piston is expelled via an exhaust manifold into another cylinder where it is compressed further rather than vented through an exhaust line. Because the piston in the boosted cylinder compresses air drawn in through its intake valve as well as additional air forced in from another cylinder, it must compress a greater

total volume of air than a piston in a conventional engine braking scheme. This places even greater retarding torque on the engine, making boosted braking a highly effective method of reducing engine speed.

5 However, because the pistons in a boosted engine braking scheme compress more air than they would in a conventional scheme, and the air is already heated from compression in another cylinder, temperatures inside the boosted cylinder can become extremely high, reaching or exceeding the tempering temperature of the  
10 metal used in conventional fuel injectors.

Referring to Figure 1, there is shown a portion of injector 10 including its tip 12 which would be exposed in a combustion space in the  
15 preferred embodiment of the present invention. During boosted compression release braking, tip 12 is exposed to temperatures at or exceeding the tempering temperature of the metal of which it is comprised. Because a metal loses its enhanced hardness when  
20 reheated to its tempering temperature, an unshielded injector tip is likely to soften when exposed to the high temperatures produced in a boosted compression release braking event.

In injector 10, needle valve member 22  
25 controls the spray of fuel into the combustion space. Precise control over initiation and termination of injection events requires needle valve member 22 to open and close valve seat 20 rapidly, requiring a relatively large amount of force. When the metal of  
30 an injector tip has been reheated to its tempering temperature, the repeated impacts of needle valve member 22 on valve seat 20 can distort its shape.



This distortion results in incomplete closing of valve seat 20, and therefore incomplete termination of fuel spray, which causes a decrease in fuel efficiency and an increase in undesirable engine emissions. In  
5 extreme cases, the loss of tempering in the injector tip can cause accelerated fatigue, which can lead the tip to break off, resulting in catastrophic engine failure.

The present invention overcomes these  
10 problems by attaching a ceramic insulator 16 to tip 12, protecting tip 12 from the extreme temperatures which are reached in the combustion space particularly during a boosted engine braking event. Insulator 16 is preferably attached to injector tip 12 in such a  
15 way that it protects the area vulnerable to distortion, which extends from plane 15 over the outer surface 13 of tip 12 to a point beyond valve seat 20. During a two-cycle boosted engine braking event, when the injector tip temperatures are highest, insulator  
20 16 prevents the vulnerable portion of tip 12 from reaching its tempering temperature.

Those skilled in the art will appreciate that various modifications could be made to the disclosed embodiments without departing from the  
25 intended scope of the present invention. For instance, rather than attaching the insulator only above the nozzle outlets, an insulator might be provided that covered the nozzle outlets, but allowed fuel to spray through perforations. Further, in  
30 addition to the engine disclosed herein, other engines and engine applications where extreme temperatures are reached in the combustion chamber might benefit

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Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	